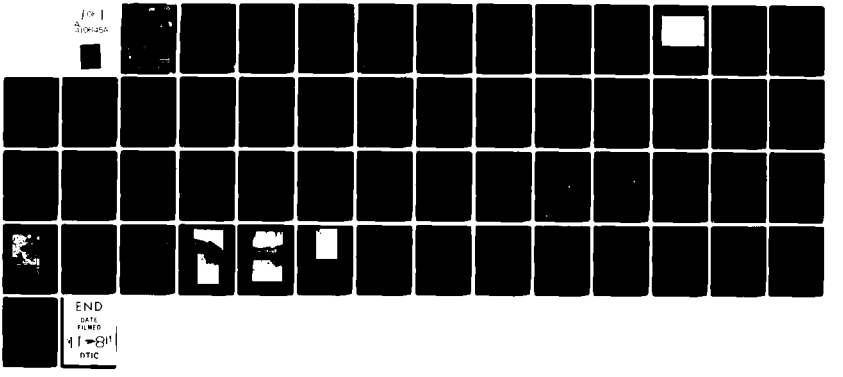
AD-A106 454 WOODWARD-CLYDE CONSULTANTS CHICAGO IL F/G 13/13
NATIONAL DAM SAFETY PROGRAM. DITCH CREEK DAM (MO 30726), MISSIS--ETC(U)
AUG 80 R G BERGGREEN, J PEREZ DACW43-80-C-0066
UNCLASSIFIED NL



END
DATE FILMED
11-81
DTIC

LEVEL II

MISSISSIPPI-KASKASKIA-ST. LOUIS BASIN

AD A104144

DITCH CREEK DAM

WASHINGTON COUNTY, MISSOURI

MO. 30726

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY INSPECTION

United States Army
Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

"Original contains color plates: All DTIC reproductions will be in black and white"

AUGUST 1980

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A106 454	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) Phase I Dam Inspection Report National Dam Safety Program Ditch Creek Dam (MO 30726) Washington County, Missouri	5. TYPE OF REPORT & PERIOD COVERED Final Report. 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) Woodward-Clyde Consultants	8. CONTRACT OR GRANT NUMBER(s) DACW43-80-C-0066
9. PERFORMING ORGANIZATION NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Engineer District, St. Louis Dam Inventory and Inspection Section, LMSED-PD 210 Tucker Blvd., North, St. Louis, Mo. 63101	12. REPORT DATE August 1980 13. NUMBER OF PAGES Approximately 70
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE
16. DISTRIBUTION STATEMENT (of this Report) Approved for release; distribution unlimited.	
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)	
18. SUPPLEMENTARY NOTES	
19. KEY WORDS (Continue on reverse side if necessary and identify by block number) Dam Safety, Lake, Dam Inspection, Private Dams	
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.	

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 TUCKER BOULEVARD, NORTH
ST. LOUIS, MISSOURI 63101

REPLY TO ATTENTION OF

SUBJECT: Ditch Creek Dam (MO 30726)

This report presents the results of field inspection and evaluation of Ditch Creek Dam. It was prepared under the National Program of Inspection of Non-Federal Dams.

The inspection results indicate problems with the spillway adequacy. Although the dam is capable of passing the PMF without overtopping, the lack of a proper spillway and discharge channel and the need to pass runoff over a public transportation route (State Highway H) indicates a deficiency at this facility.

SUBMITTED BY: SIGNED
Chief, Engineering Division — 25 SEP 1980 Date

APPROVED BY: SIGNED
Colonel, CE, District Engineer — 26 SEP 1980 Date

DITCH CREEK DAM

Washington County, Missouri

Missouri Inventory No. 30726

Phase I Inspection Report

National Dam Safety Program

Prepared by

Woodward-Clyde Consultants

Chicago, Illinois

Under Direction of

St Louis District, Corps of Engineers

for

Governor of Missouri

August 1980

PREFACE

This report is prepared under guidance contained in the Recommended Guidelines for Safety Inspection of Dams for Phase I Investigations. Copies of these guidelines may be obtained from the Office of the Chief of Engineers, Washington, D. C., 20314. The purpose of a Phase I investigation is not to provide a complete evaluation of the safety of the structure nor to provide a guarantee on its future integrity. Rather the purpose of the program is to identify potentially hazardous conditions to the extent they can be identified by a visual examination. The assessment of the general condition of the dam is based upon available data (if any) and visual inspections. Detailed investigations, testing, and detailed computational evaluations are beyond the scope of a Phase I investigation; however, the investigation is intended to identify the need for more detailed studies. In view of the limited nature of the Phase I studies no assurance can be given that all deficiencies have been identified.

In reviewing this report, it should be realized that the reported condition of the dam is based on observations of field conditions at the time of inspection along with any data which may be available to the inspection team. In cases where the reservoir was lowered or drained prior to inspection, such action removes the normal load on the structure, as well as the reservoir head along with seepage pressures, and may obscure certain conditions which might otherwise be detectable if inspected under the normal operating environment of the structure.

It is important to note that the condition of a dam depends on numerous and constantly changing internal and external conditions, and is evolutionary in nature. It would be incorrect to assume that the present condition of the dam will continue to represent the condition of the dam at some point in the future. Only through frequent inspections can unsafe conditions be detected, so that corrective action can be taken. Likewise continued care and maintenance are necessary to minimize the possibility of development of unsafe conditions.

PHASE I REPORT
NATIONAL DAM SAFETY PROGRAM

Name of Dam	Ditch Creek (Mononame 559) Dam
State Located	Missouri
County Located	Washington
Stream	Unnamed Tributary of Ditch Creek
Date of Inspection	4 June 1980

Ditch Creek Dam, Missouri Inventory number 30726 was inspected by Richard Berggreen (engineering geologist), David Hendron (geotechnical engineer) and Sean Tseng (hydrologist).

The dam inspection was made following the guidelines presented in the "Recommended Guidelines for Safety Inspection of Dams". These guidelines were developed by the Chief of Engineers, U.S. Army, Washington, D.C., with the help of federal and state agencies, professional engineering organizations, and private engineers. The resulting guidelines represent a consensus of the engineering profession.

Based on the criteria in the guidelines, the dam is judged to be in the high hazard classification. The St Louis District, Corps of Engineers (SLD) has estimated the potential damage zone to extend approximately 13 mi downstream of the dam. The nearest occupied structure is 0.1 mi below the dam but its elevation appears to be above the potential damage zone. Missouri State Highway H crosses the downstream channel 0.1 mi downstream of the dam. The population within the 13 mi damage zone designated by SLD indicates that significant loss of property and life is possible in the event of overtopping and failure of the dam.

Ditch Creek Dam is an abandoned barite tailings dam. The dam is in the intermediate size classification based on its maximum height of 60 ft.

Our inspection and evaluation indicate the dam is in generally fair to good condition. There is no formal spillway or other outlet facilities at this dam. This is considered a deficiency. A low area to the west of the left dam abutment acts as an informal spillway. This is considered a deficiency. The cohesionless nature of the coarse tailings comprising

the embankment indicates the dam could be significantly eroded if overtopped. The hydrologic analysis, however, shows the dam embankment will not be overtopped by a flood with 1 percent probability-of-occurrence or by the Probable Maximum Flood (PMF), because the flood waters would pass over the informal spillway. The PMF is defined as the flood event that may be expected to occur from the most severe combination of critical meteorologic and hydrologic considerations that are reasonably possible in the region.

Mining operations have encroached on approximately 200 ft of the downstream toe of the dam and have resulted in steep slopes at that location. This mining appears to have been discontinued approximately 2 years ago. The steep slopes at the downstream toe of the dam could result in landslides on the face of the embankment.

It is recommended that, as a minimum, the following studies be made and the following actions be taken under the guidance of an engineer experienced in design and construction of dams:

1. Design and construction of a formal spillway and discharge channel required to pass an appropriate design flood, as an alternate to the present condition where a low area to the west of the left abutment of the dam acts as an informal spillway; consideration should be given to the erodibility of the embankment and spillway.

2. Assessment of the effects of mining at the toe of the dam by an appropriate slope stability analysis.

3. Establishment of a plan for removal of trees and brush on the face of the dam to prevent deleterious effects on slope stability and to permit proper inspection of the face; removal of large trees and indiscriminate clearing must be carefully planned as this may jeopardize the long-term stability of the dam.

4. Analysis of the static and seismic stability of the dam and of the effects of seepage on the stability of the dam, in accordance with the requirements of the guidelines.

5. Initiation of a program of periodic inspection and monitoring for this facility. This program should include, but not be limited to, the following:

a. Monitoring seepage at the toe of the dam to identify changes in the amount of flow or turbidity of the seepage water;

b. Inspecting the embankment periodically to identify slumping or evidence of instability in the areas where cracks were observed and where mining activities have resulted in oversteepened slopes; and

c. Performing maintenance work as needed on the basis of the recommended inspection program.

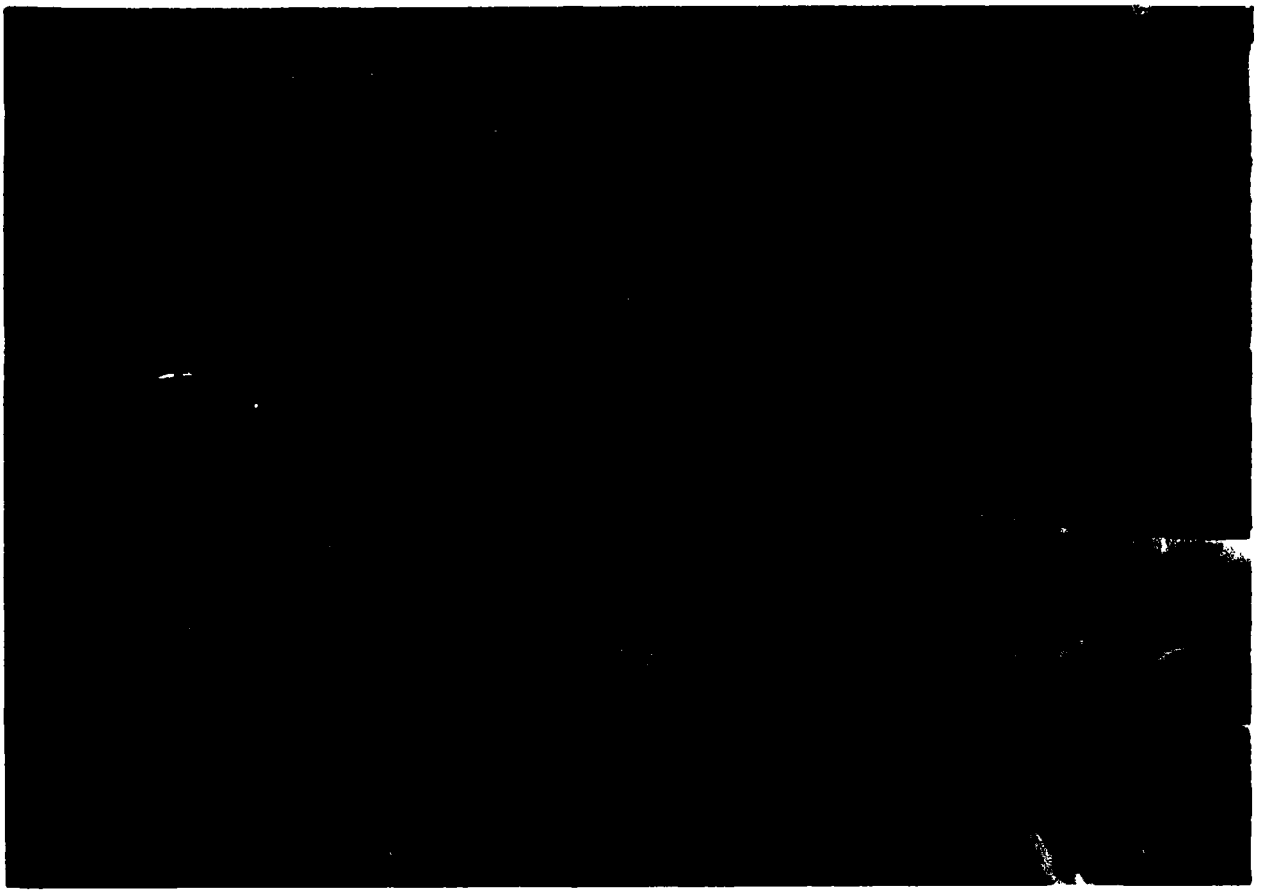
6. Assessment of the practicality of establishing a warning system for advising downstream residents and traffic should unsafe emergency conditions develop at the dam.

It is recommended that the owner take action on these recommendations without undue delay.

WOODWARD-CLYDE CONSULTANTS

Richard G. Berggreen
Registered Geologist

Jean-Yves Perez, PE
Project Manager



OVERVIEW
DITCH CREEK DAM

MISSOURI INVENTORY NUMBER 30726

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
DITCH CREEK DAM, (MO. 30726)

TABLE OF CONTENTS

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
DITCH CREEK DAM, MISSOURI ID. NO. 30726

SECTION 1
PROJECT INFORMATION

1.1 General

a. **Authority.** The National Dam Inspection Act, Public Law 92-367, provides for a national inventory and inspection of dams throughout the United States. Pursuant to the above, an inspection was conducted of the Ditch Creek Dam, Missouri inventory number 30726.

b. **Purpose.** "The primary purpose of the Phase I investigation program is to identify expeditiously those dams which may pose hazards to human life or property... The Phase I investigation will develop an assessment of the general condition with respect to safety of the project based upon available data and a visual inspection, determine any need for emergency measures and conclude if additional studies investigations and analyses are necessary and warranted." (Chapter 3, Recommended Guidelines for Safety Inspection of Dams).

c. **Evaluation criteria.** The criteria used to evaluate the dam were established in the "Recommended Guidelines for Safety Inspection of Dams", Engineering Regulation No. 1110-2-106 and Engineering Circular No. 1110-2-188, Engineering and Design, National Program for Inspection of Non-Federal Dams, by the Office of Chief of Engineers, Department of the Army; and "Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams" prepared by the St Louis District Corps of Engineers (SLD). These guidelines were developed with the help of several federal agencies and many state agencies, professional engineering organizations, and private engineers.

1.2 Description of Project

a. **Description of dam and appurtenances.** Ditch Creek Dam is an abandoned barite tailings dam. Its construction procedure and its usage are typical of other such dams in the area. A brief description of the general construction procedure and usage of Missouri barite tailings dams is necessary to appreciate the unique nature of these dams and understand the differences between these dams and more conventional water-retaining dams.

At the start of a barite mining operation in this area, a 10 to 20-ft high starter dam is typically first constructed across a natural stream channel. Generally the streams are intermittent so that construction is carried out in the dry. Trees and other vegetation are removed from the dam site and then a cutoff is often made to shallow bedrock. Locally obtained earth, usually a gravelly clay, is then placed to form the embankment. Compaction is limited to that provided by the construction equipment.

The barite ore is found at shallow depth within the residual gravelly clay which is mined with earth-moving equipment. At the processing plant, the ore is washed to loosen and remove the soil. This water is obtained from the reservoir area behind the dam. The soil-laden, wash water and water from other steps in the process is then discharged into the reservoir. There, the soil is deposited by sedimentation and the water recycled. Another step in the process removes the gravel-sized waste which is called "chat".

As the level of the fine tailings impounded in the reservoir increases, the dam is raised. The usual method is to dump chat on the dam crest. The chat is spread over the crest so that a relatively constant crest width is maintained as the dam is raised. Generally the crest centerline location is also maintained. However, the crest centerline location will move upstream if there is insufficient chat available or downstream if an excessive quantity of chat is available. The latter is uncommon because it is indicative of a poor ore deposit.

This method of construction results in embankment slopes which are close to the natural angle of repose for the chat. They can be considered to be near a state of incipient failure.

A large quantity of water is required for barite processing, on the order of 2000 to 5000 gal/min. Thus, it has been the operators' practice to construct the dam so that all inflow to the reservoir is recycled in order to have sufficient water for the operation. The result is that formal spillways or regulating outlets are generally not constructed. In some cases a low point on or near the dam is provided should the reservoir storage capacity be exceeded.

The fine tailings typically fill more than 80 percent of the total storage volume. This results from the operator's practice of maintaining only a 2 to 5 ft elevation differential between the level of the tailings and the dam crest.

The geotechnical characteristics of the fine tailings are somewhat similar to recent lacustrine clay deposits. Where the tailings have been continuously submerged, they have a very soft consistency and high water contents. When evaporation causes the water level to recede and the tailings are exposed, a stiff crust forms as the tailings dry out. Below the crust, the tailings retain their soft consistency for long periods of time.

Ditch Creek Dam is approximately 2700 ft long and borders the impoundment area on the north and east. It is approximately 60 ft high at the maximum section. No low level outlet was observed during our inspection of Ditch Creek Dam. There is no formal spillway or discharge channel for this dam. An "informal spillway" was taken as a low area to the west of the northwestern end of the chat embankment (see Fig. 3a). The elevation of this informal spillway was taken as 852. This elevation is approximately the same elevation as the impounded tailings. No control structure exists at this overflow area. Therefore, a substantial rainfall will induce flow northward over the informal spillway and into a mined-out depression just to the south of State Highway H. Because storage capacity of the mined-out area is relatively small, the outflow will be assumed to pass over a low area on the highway surveyed at elevation 846. This outflow will then be directed

northward into the Richwoods Pond Dam impoundment (Missouri inventory number 20727) where the flow will contribute to the Richwoods Pond storage and outflow.

b. **Location.** The dam is located approximately 2.3 mi ENE of the town of Richwoods, Washington County, Missouri. The dam location is on USGS Richmond NE, 7.5 minute quadrangle sheet (advance print), Section 34, T40N, R02E; see Fig. 1.

c. **Size classification.** The dam is classified intermediate size based on its 60 ft height.

d. **Hazard classification.** SLD has classified the dam as a high hazard dam; we concur with this classification. The limit of the potential damage zone is estimated to be 13 mi downstream. Several occupied structures are located within this zone, including five dwellings. The closest occupied structure is 0.1 mi downstream of the dam; however, its elevation appears to be above that of the damage zone. State Highway H runs along the northwestern end of the dam and will be flooded during high flows.

e. **Ownership.** The dam is owned by Desoto Minerals Co, Box 35, Richwoods, Missouri, 63071. Correspondence should be addressed to Mr Durward Spees.

f. **Purpose of dam.** The dam was constructed to impound fine barite tailings produced by the washing of barite ore mined in the vicinity. Water was recycled from the reservoir and used in the barite processing operation. It is currently abandoned.

g. **Design and construction history.** The present owner has no record of the design and construction of the dam. Mr Robert Griffey of Pfizer Inc, a past operator of the mine, has stated that the mine was deactivated in 1955. This is supported by the size of the trees growing in the tailings area which appear to be about 25 years old.

h. **Normal operating procedures.** No operating records were found. The dam is currently abandoned and there are no operating facilities at this site.

1.3 Pertinent Data

a. **Drainage area.** approximately 0.20 mi^2

b. **Discharge at dam site.**

Maximum known flood at damsite	Unknown
Warm water outlet at pool elevation	N/A
Diversion tunnel low pool outlet at pool elevation	N/A
Diversion tunnel outlet at pool elevation	N/A
Gated spillway capacity at pool elevation	N/A
Gated spillway capacity at maximum pool elevation	N/A
Ungated spillway capacity at maximum pool elevation	N/A see Sect. 5.1.d
Total spillway capacity of maximum pool elevation	N/A see Sect. 5.1.d

c. **Elevations (ft above MSL).**

Top of Dam	855 to 864
Maximum pool - design surcharge	N/A
Full flood control pool	N/A
Recreation pool	N/A
Spillway crest (gated)	N/A
Upstream portal invert diversion tunnel	N/A
Downstream portal invert diversion tunnel	N/A
Streambed at centerline of dam	Unknown
Maximum tailwater	N/A
Toe of dam at maximum section	800

d. **Reservoir.**

Length of maximum pool	3000 ft
Length of recreation pool	N/A
Length of flood control pool	N/A

e. **Storage (acre-feet).**

Recreation pool	N/A
Flood control pool	N/A
Design surcharge	N/A
Top of dam	207

f. **Reservoir surface (acres).**

Top of dam	approximately 18 at el 852
Maximum pool	approximately 18 at el 852
Flood control pool	N/A
Recreation pool	N/A
Spillway crest	approximately 18 at el 852

g. **Dam.**

Type	Tailings
Length	approximately 2,700 ft
Height	60 ft
Top width	15 to 25 ft
Side slopes	D/S 1.5H to 1V; U/S Unknown
Zoning	Unknown (probably none)
Impervious core	Unknown (probably none)
Cutoff	Unknown
Grout curtain	Unknown (probably none)

h. **Diversion and regulating tunnel.**

Type	None
Length	N/A
Closure	N/A
Access	N/A
Regulating facilities	None

i. **Spillway.**

Type	No formal spillway has been constructed for this dam. The informal spillway consists of residual soils, moderately vegetated.
Length of weir	approximately 500 ft (informal spillway)
Crest elevation	852 ft (informal spillway)
Gates	None
Downstream channel	There is no well-defined channel. Flow through informal spillway is directed across Highway H into Richwoods Pond Dam impoundment, Missouri, ID. No. 30727

j. **Regulating outlets.**

None.

SECTION 2
ENGINEERING DATA

2.1 Design

No design drawings or other design data were found.

2.2 Construction

No construction records were found.

2.3 Operation

No operation records were found. The dam is presently abandoned.

2.4 Evaluation

a. **Availability.** No engineering data were available for review.

b. **Adequacy.** The available information is insufficient to evaluate the design of Ditch Creek Dam. Seepage and stability analyses comparable to the requirements of the guidelines are not on record. This is a deficiency which should be rectified. These seepage and stability analyses should be performed for appropriate loading conditions (including earthquake loads) and made a matter of record. These analyses should be performed by an engineer experienced in the design and construction of dams.

c. **Validity.** Not applicable.

2.5 Project Geology

The dam site lies on the northern flank of the Ozark structural dome. The regional dip is to the north. The bedrock in the area is mapped as Cambrian age Eminence

and Potosi dolomite formations on the Geologic Map of Missouri (Fig. 4). The Potosi Formation typically contains an abundance of quartz druse characteristic of chert bearing formations. The Eminence Formation conformably overlies the Potosi Formation, and contains less quartz and chert.

The soil at the dam site is a dark red-brown, plastic residual clay (CH), characteristically developed on the Potosi Formation. It is locally overlain by a 1 to 5 ft thick silty loess soil profile. The area is mapped on the Missouri General Soils Map as Union-Goss-Gasconade-Peridge Association.

The Richwoods Fault Zone lies approximately 1.5 mi south of the dam site and is mapped on the Structural Features Map of Missouri (1971) as discontinuous for approximately 19 mi, in a WNW-ESE direction. The Ditch Creek Fault System is located about 3.5 mi north of the site and is mapped on the Structural Features Map as approximately 11 mi long, paralleling the Richwoods Fault zone. The Ditch Creek System is mapped as north side down; the Richwoods fault is mapped as north side up. These faults are Pre-Cambrian in age and not in a seismically active area.

SECTION 3
VISUAL INSPECTION

3.1 Findings

a. **General.** Ditch Creek Dam was inspected on 4 June 1980. No owner's representative was present. This inspection indicated the dam is in generally fair to good condition.

b. **Dam.** The embankment is constructed of coarse tailings, locally called "chat". This material (sandy gravel and sand, GW-SW) is generally cohesionless and permeable. Portions of the face of the dam are covered with "bullrock", coarse tailings typically over 6 inches in diameter in a clay matrix.

The majority of the dam crest and face is densely vegetated with brush and trees. Some trees have trunk diameters greater than 24 inches. The dense vegetation obscured the view of much of the dam.

The vertical and horizontal alignment of the dam crest appears undisturbed. The surface of the dam, where visible through the vegetation, appears hummocky in some locations. It could not be determined whether these features were due to construction techniques or slumping on the face of the dam.

An area of cracking on the dam crest, approximately 15 ft long, with approximately 0.3 ft of offset down toward the downstream face of the dam was identified near the right abutment (see Photo 5, Appendix A).

Past mining activities have encroached upon the toe of the dam near the left abutment as the observer faces downstream (Photo 3, Appendix A). This mining has left a 20-ft high 1H to 1V slope in the residual clay soil at the toe of the dam. The total length of the mined area is approximately 200 ft. It is estimated by vegetative growth that the mining at the toe of the dam was

discontinued around 1978. Minor amounts of seepage, estimated at 2 to 4 gal/min, were noted in this mined area. The seepage water did not appear to be carrying any soil.

Several shallow animal burrows, up to 2 ft deep, were noted on the crest of the dam.

No evidence of significant erosion or sinkhole development was noted during the visual inspection.

c. **Appurtenant structures.** No formally designed or constructed appurtenant structures such as a spillway or discharge channel exists at this dam. The informal spillway is in a low area to the west of the dam. The soil in the area of the informal spillway is partially vegetated by grass, brush and small trees. This area is shown to the right of Photograph 4 (Appendix A). Where the soil is not vegetated, its erosion potential will be high because it is fine-grained and has little true cohesion. Vegetated areas will be moderately susceptible to erosion.

d. **Reservoir area.** The majority of the surface area of the impoundment was above the water level at the time of inspection. This area is underlain by tailings which consist of a relatively impervious mixture of silt, sand and clay. A dense growth of trees and brush are present in this portion of the reservoir area.

In the flooded area, maximum water depth was estimated at about 5 ft at the time of inspection.

Slopes surrounding the reservoir area are quite flat and estimated to be flatter than 5H to 1V. No indication of potential instability was observed on slopes surrounding the reservoir area.

e. **Downstream channel.** The channel below the dam flows through a sparsely populated, wooded, rural area. It is an intermittent stream valley. An occupied structure is located 0.1 mi downstream of the dam and is judged to be above the damage zone. The apparent discharge of outflow for this dam is northward into a mined-out depression and then it crosses Missouri State Highway H about 800 ft west of the north end of the dam and continues into the impoundment for Richwoods Pond Dam, Missouri inventory number 30727 (Fig. A-1, Appendix A). The low elevation on Highway H was surveyed at 846 ft MSL.

3.2 Evaluation

Our evaluation indicates that the dam is in generally fair to good condition. The heavy vegetation on the dam may obscure minor sloughs and small cracks. Growth of trees having deep root systems is considered to be a potential problem. The trees and brush should be removed to better identify evidence slope instability. Removal of large trees should be done under the guidance of an engineer experienced in the design and construction of dams. Indiscriminate clearing could jeopardize the safety of the dam.

There is no formal spillway or downstream channel for this dam. This is considered a deficiency. Outflow is directed northward through an informal spillway, into a mined-out depression and then over State Highway H, into the Richwoods Pond Dam impoundment. The cohesionless nature of the coarse tailings (chat) comprising the embankment suggests the dam would be severely eroded if overtopped. Erosion of the informal spillway is expected to be moderate to high.

Seepage at the toe of dam did not appear to constitute a hazard due to its low rate of flow and lack of soil in the flow.

Mining operations which have encroached on the toe of the dam should not be reactivated. An analysis of the static stability the dam is required to evaluate the effect of this mining on the long-term stability of the dam.

SECTION 4
OPERATIONAL PROCEDURES

4.1 Procedures

No operating procedures currently exist at this facility as the dam has been abandoned.

4.2 Maintenance of Dam

No maintenance is performed as dam has been abandoned. There is no planned maintenance in the future.

4.3 Maintenance of Operating Facilities

There are no facilities requiring mechanical operation at this dam.

4.4 Description of Any Warning System in Effect

Our visual inspection did not disclose any warning system in effect at this dam.

4.5 Evaluation

There is no plan for periodic inspections and performance of maintenance on this dam. In view of the abandoned nature of the dam and the erodability of the embankment, this is considered a deficiency.

SECTION 5
HYDRAULIC/HYDROLOGIC

5.1 Evaluation of Features

a. **Design data.** No hydrologic or hydraulic design information was available for evaluation of the dam or the reservoir. Topographic maps prepared in February 1980 by Desoto Mining Company were used in our analyses. Other dimensions of the dam and reservoir were measured and/or surveyed on the date of inspection or estimated from USGS topographic mapping. The map used in the analysis is the advance print of the USGS 7.5 minute Richwoods NE quadrangle sheet.

b. **Experience data.** No recorded rainfall, runoff, discharge, or pool stage data were available for this reservoir dam.

c. **Visual observations.**

1. Watershed. Much of the area adjacent to the highway is a densely vegetated, irregularily mined area. It is likely some retardation of outflow would occur in the event of the occurrence of a large flood. The remainder of the watershed consists of mined areas that have been partially reclaimed by nature.

2. Reservoir. The reservoir consists of mostly exposed fine-grained tailings that are saturated or desiccated at the surface. The above-water area covers about 90 percent of the total reservoir area and is heavily vegetated by bushes, cattails, saplings and mature trees.

3. Spillway. There is no formal spillway at this facility. The terminology "informal spillway" has been assigned to the low area to the west of the dam (see Figs. 3a and 3b). This overflow area has a moderate to high erosion potential as the stoney clay residual soil is only moderately vegetated. This soil has been observed to be highly erodible when stripped of vegetation and exposed to flow velocities of over 5 ft/sec.

The channel downstream of the dam is poorly defined. Flows will be directed from the informal spillway over State Highway H and into the impoundment of the Richwoods Pond Dam, Missouri inventory number 30727.

4. Seepage. The magnitude of seepage through this dam is not hydraulically significant to the overtopping analysis of this dam.

d. **Overtopping potential.** The lack of a designed, formal spillway and discharge channel and the need to pass runoff over a public transportation route indicate a deficiency at this facility. It is recommended that a hydrologic analysis be conducted to facilitate the design of a spillway and discharge channel adequate to pass the PMF.

Downstream from the dam, the drainage flows through a sparsely populated, wooded, rural area. One occupied structure is located approximately 0.1 mi below the dam, adjacent to Highway H, but is judged to be above the potential damage zone. Beyond this, the nearest occupied structures are located 4 or more miles downstream.

For the purpose of the overtopping analysis, the elevation of the top of the dam was taken at 852, which is in fact the controlling elevation of the informal spillway. The chat embankment crest varies, actually, between el 855 at the left abutment, to el 864 near the maximum dam section. Overtopping was found to occur for virtually any substantial precipitation event. Overtopping, in this analysis, means outflow around the left abutment through the informal spillway. The chat embankment itself will not be overtopped.

Hydraulic and hydrologic analysis indicate that all fractions of the PMF overtop the dam through the informal spillway. The PMF is defined as the flood event that may be expected to occur from the most severe combination meteorologic and hydrologic conditions that are reasonably possible in the region. Outflow will cross the low section on Missouri Highway H and flow into the impoundment for Richwoods Pond Dam, Missouri Inventory number 30727.

Flow velocities computed for the various outflows indicate that significant erosion of the spillway will occur for storms greater than 50 percent of the PMF. This erosion will lower the spillway crest elevation and transport soil and tailings from the reservoir into a mined-out depression south of State Highway H. An indefinite amount of the soil and tailings will remain suspended and transported over Highway H and into the Richwoods Pond dam impoundment. Significant erosion of the chat portion of the dam is not expected to occur.

The following overtopping data for selected precipitation events were computed for the dam, assuming no erosion of the spillway or dam embankment:

Precipitation Event	Max Reservoir W.S. Elevation ft	Max Depth over Embankment, ft	Max Depth Over Informal Spillway ft	Maximum Outflow ft^3/s	Max Velocity of Outflow ft/sec	Duration of Overtopping hr
100% PMF	853.5	0	1.5	1260	5.7	48*
50% PMF	853.1	0	1.1	620	4.9	48*

* Since the starting water surface elevation is at the spillway crest elevation, the duration of overtopping will always be approximately equal to the storm duration.

Details of the hydraulic and hydrologic analyses are given in Appendix B.

SECTION 6
STRUCTURAL STABILITY

6.1 Evaluation of Structural Stability

a. **Visual observations.** Features identified during the visual inspection which adversely affect the structural stability of this dam are reported in Section 3. The most important adverse features include mining at the toe of the dam and cracking noted on the crest of the embankment.

b. **Design and construction data.** No design or construction data relating to the structural stability of the dam were found.

c. **Operating records.** No appurtenant structures requiring operation exist at this dam. Static and seismic stability analyses are not on record. This is a deficiency which should be corrected.

d. **Post construction changes.** Following construction of the dam, mining was conducted near the toe of the left abutment. This mining encroached on the dam in several places (Fig. A-1, Appendix A). At one location a 20-ft high 1H to 1V cut face exists immediately adjacent to the toe of the dam. This mining has been discontinued for an estimated two years. The lack of a static or seismic stability analysis precludes an adequate evaluation of the effect of this mining on the stability of the dam.

Other post construction changes are limited to clearing of vegetation and mining in the area surrounding the reservoir. Siltation which will result from removal of the vegetation and soil is not likely to significantly affect the tailings impoundment drainage regime.

e. **Seismic stability.** The dam is in Seismic Zone 2, to which the guidelines assign a moderate damage potential. Since no static stability analysis is available for review, the seismic stability cannot be evaluated. However, as the tailings are

fine-grained, saturated materials and the dam is made of loose, granular material resting near its natural angle of repose, substantial deformation leading to damage or failure could occur in the event of a severe seismic event.

SECTION 7
ASSESSMENT/REMEDIAL MEASURES

7.1 Dam Assessment

a. **Safety.** Based on the visual inspection, Ditch Creek Dam appears to be in generally fair to good condition. This designation is based primarily on the lack of a designed spillway or other outlet works, and the mining encroachment at the toe of the dam near the left abutment.

As a consequence of the widely-used construction procedure, the downstream slopes of the tailings dams are placed at or near the angle of natural repose for the "chat" material. This results in slopes that are very steep and exist in a state close to incipient failure with safety factors close to one. The slopes placed at angle of natural repose will only remain stable, if they are protected against potential harmful changes, among which are:

1. Overtopping by water
2. Higher pore pressures (or seepage forces)
3. Undercutting of the toe of the slope by erosion or mining activity
4. Increase in the height of the slope
5. Harmful effects of vegetation (particularly tree roots)
6. Liquefaction (such as may result from a seismic event).

The first five changes are subject to control by owners and operators and must receive careful attention in order to maintain stable and safe dam embankments. The sixth influence represents a risk the magnitude of which is not well understood without further study.

Factors which further affect the safety of the dam are the amount of consolidation and desiccation of the fine-grained tailings. Over a period of time, desiccation and consolidation decreases the lateral loads on the dam and increases the strength of the tailings. This increases the factor of safety of

the structure against failure. The magnitude of this increase is unknown without further tests and study.

b. **Adequacy of information.** The visual inspection provided a reasonable base of information for the recommendations and conclusions presented in this Phase I report. The lack of stability and seepage analyses for the dam as recommended by the guidelines preclude an evaluation of the structural and seismic stability of the dam. This is a deficiency which should be rectified.

c. **Urgency.** The deficiencies described in this report could affect the safety of the dam. Corrective actions should be initiated without undue delay.

d. **Necessity for Phase II.** In accordance with the Recommended Guidelines for Safety Inspection of Dams, the subject investigation was a minimum study. This study revealed that additional in-depth investigations are needed to complete the assessment of the safety of the dam. Those investigations which should be performed without undue delay are described in Section 7.2b. It is our understanding from discussions with the St Louis District that any additional investigations are the responsibility of the owner.

7.2 Remedial Measures

a. **Alternatives.** There are several general options available which may be considered to avoid the serious consequences of dam failure resulting from overtopping. These alternatives include:

1. Remove or breach the dam;

2. Increase the height of the dam and/or spillway size to pass the probable maximum flood without overtopping the dam.

3. Purchase downstream land that would be adversely impacted by dam failure and restrict human occupancy.

4. Enhance the stability of the dam to permit overtopping without failure.

5. Provide a highly reliable flood warning system. This generally does not prevent property damage but avoids loss of life.

b. **Recommendations.** Based on our inspection of the Ditch Creek Dam, it is recommended that, as a minimum, the following studies be made and the following actions be taken under the guidance of an engineer experienced in design and construction of dams:

1. Design and construction of a formal spillway and discharge channel required to pass an appropriate design flood, as an alternate to the present condition where a low area to the west of the left abutment of the dam acts as an informal spillway; consideration should be given to the erodibility of the embankment and spillway.

2. Assessment of the effects of mining at the toe of the dam by an appropriate slope stability analysis.

3. Establishment of a plan for removal of trees and brush on the face fo the dam to prevent deleterious effects on slope stability and to permit proper inspection of the face; removal of large trees and indiscriminate clearing must be carefully planned as this may jeopardize the long-term stability of the dam.

4. Analysis of the static and seismic stability of the dam and of the effects of seepage on the stability of the dam, in accordance with the requirements of the guidelines.

5. Initiation of a program of periodic inspection and monitoring for this facility. This program should include, but not be limited to, the following:

a. Monitoring seepage at the toe of the dam to identify changes in the amount of flow or turbidity of the seepage water;

b. Inspecting the embankment periodically to identify slumping or evidence of instability in the areas where cracks were observed and where mining activities have resulted in oversteepened slopes; and

c. Performing maintenance work as needed on the basis of the recommended inspection program.

6. Assessment the practically of establishing a warning system for advising downstream residents and traffic should unsafe emergency conditions develop at the dam.

It is recommended that the owner take action on these recommendations without undue delay.

c. **O & M procedures.** Periodic inspections should be made by an engineer experienced in the construction and maintenance of dams. Particular attention should be given to areas where the cracks were observed during this inspection and where mining activities have resulted in oversteepened slopes. These inspections should include but not be limited to evaluation of slope stability such as slumping and erosion, and inspection of seepage areas to identify changes in the volume of flow or turbidity in the seepage water. Records should be kept of these inspections and of any recommended maintenance activity.

REFERENCES

Allgood, Ferris P., and Persinger, Ivan, D., 1979, "Missouri General Soil Map and Soil Association Descriptions," US Department of Agriculture, Soil Conservation Service and Missouri Agricultural Experiment Station.

Department of the Army, Office of the Chief of Engineers, 1977, EC 1110-2-188, "National Program of Inspection of Non-Federal Dams".

Department of the Army, Office of the Chief of Engineers, 1979, ER 1110-2-106, "National Program of Inspection of Non-Federal Dams".

Hydrologic Engineering Center, US Army Corps of Engineers, 1978, "Flood Hydrograph Package (HEC-1) Users Manual for Dam Safety Investigations".

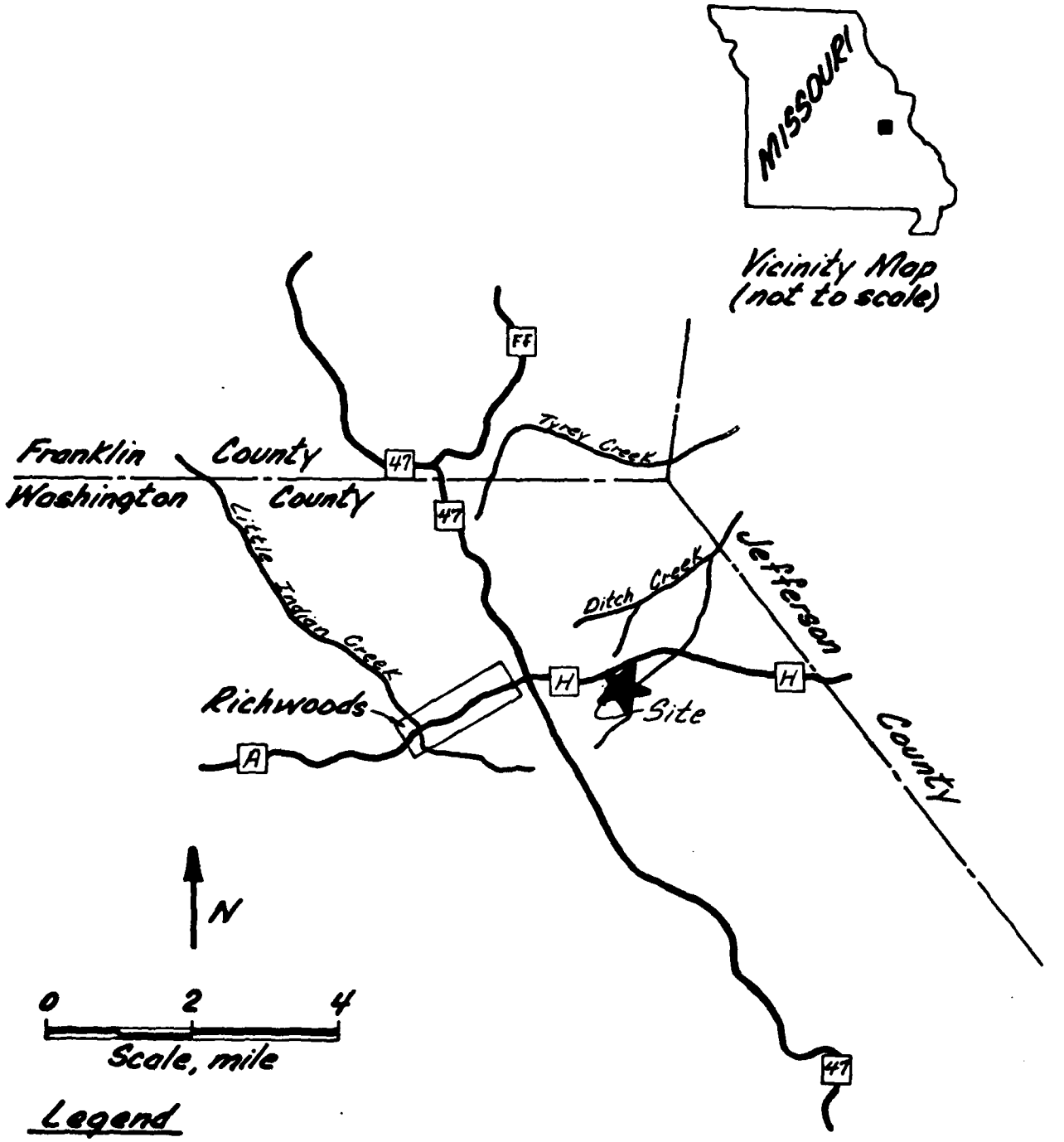
McCracken, Mary H., 1971, Structural Features Map of Missouri: Missouri Geological Survey, Scale 1:500,000.

Missouri Geological Survey, 1979, Geologic Map of Missouri: Missouri Geological Survey, Scale 1:500,000.

St Louis District, US Army Corps of Engineers, 1979, "Hydrologic/Hydraulic Standards, Phase I Safety Inspection of Non-Federal Dams".

US Department of Commerce, US Weather Bureau, 1956, "Seasonal Variation of the Probable Maximum Precipitation East of the 105th Meridian for Areas from 10 to 1,000 Square Miles and Durations of 6, 12, 24 and 48 Hours," Hydrometeorological Report No. 33.

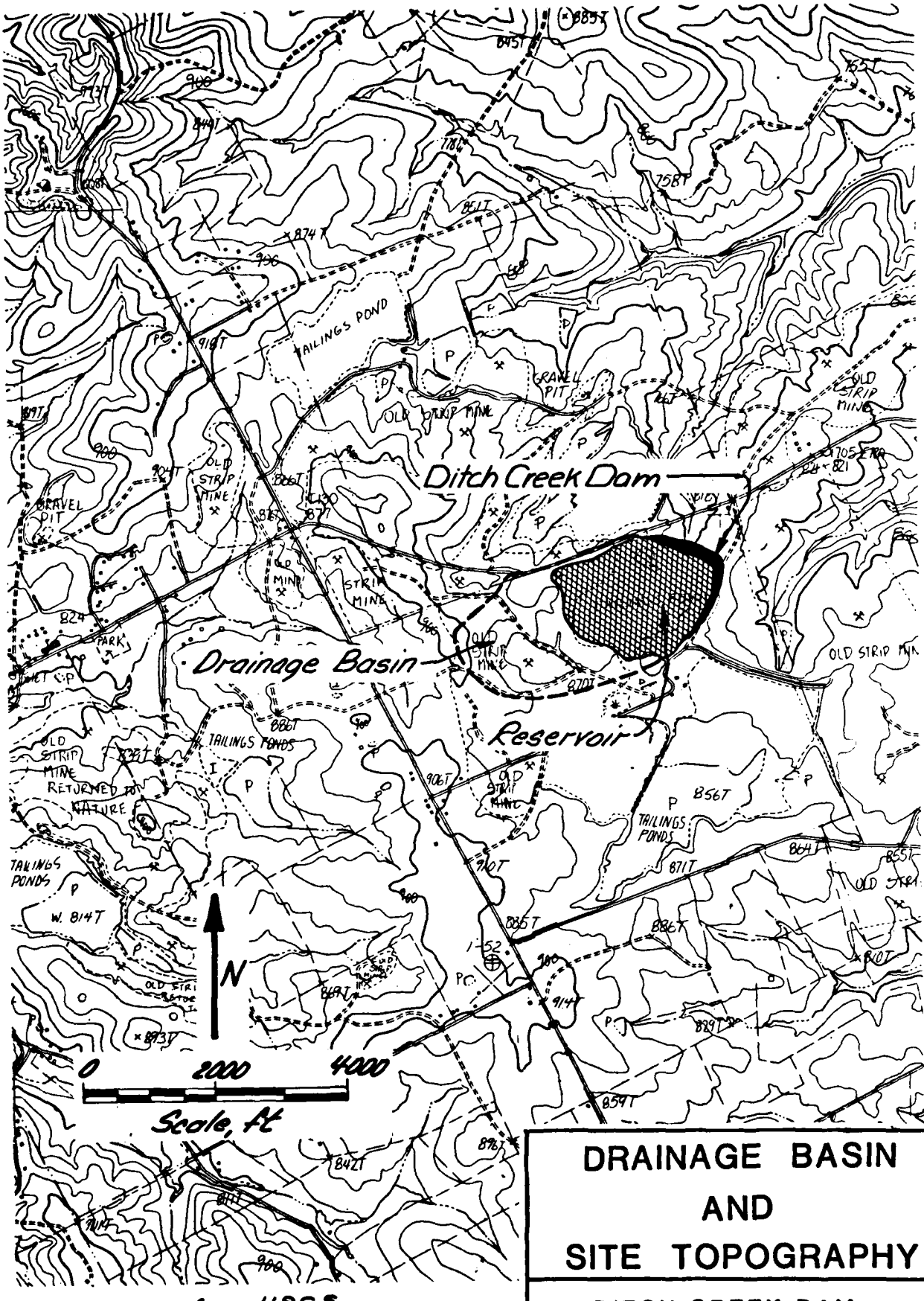
US Soil Conservation Service, 1971, "National Engineering Handbook," Section 4, Hydrology, 1971.



SITE LOCATION MAP

DITCH CREEK DAM

MO. 30726 | Fig. 1

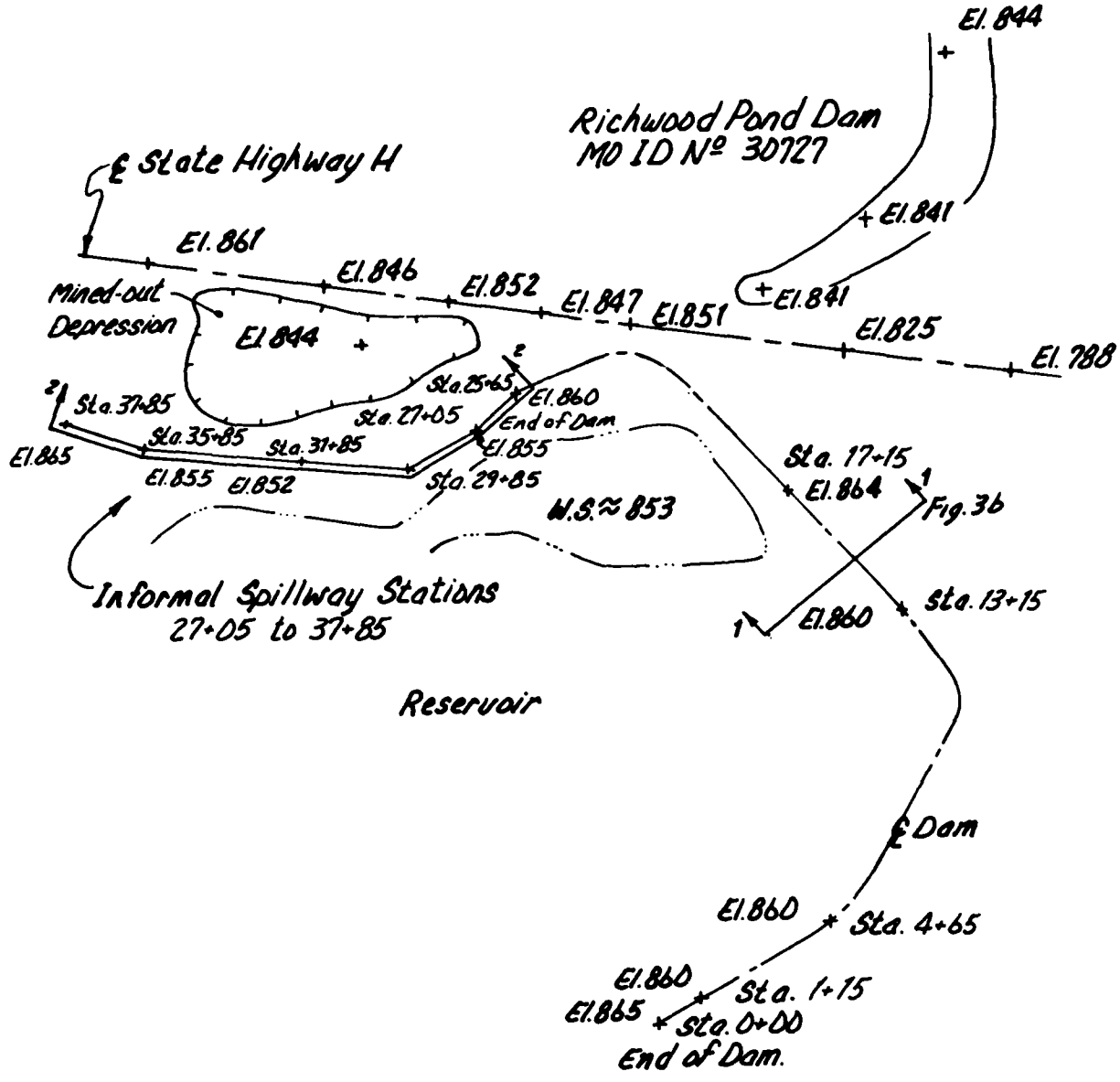


1. Topography from U.S.G.S. Richwoods N.E. 7½ minute quadrangle map.

DRAINAGE BASIN AND SITE TOPOGRAPHY

DITCH CREEK DAM

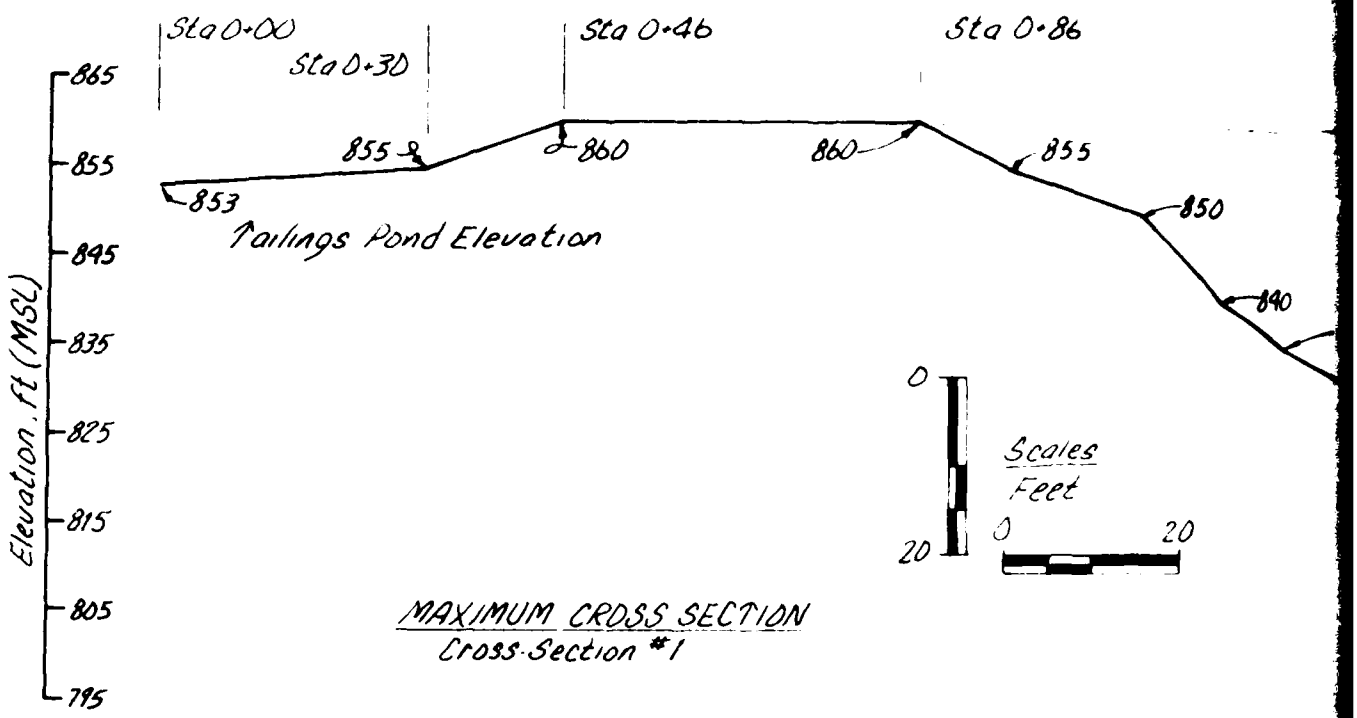
MO. 30726 | Fig. 2



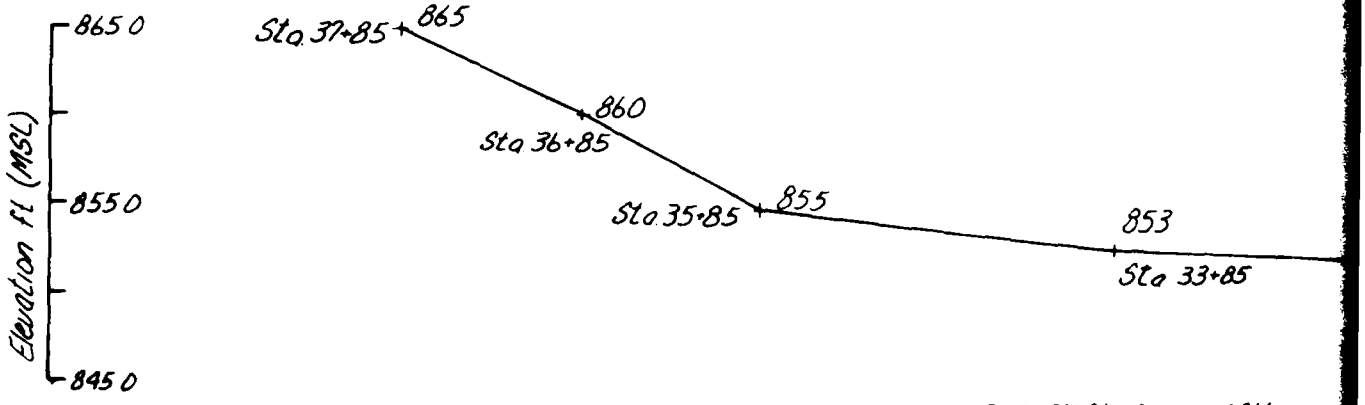
PLAN OF DAM

DITCH CREEK DAM

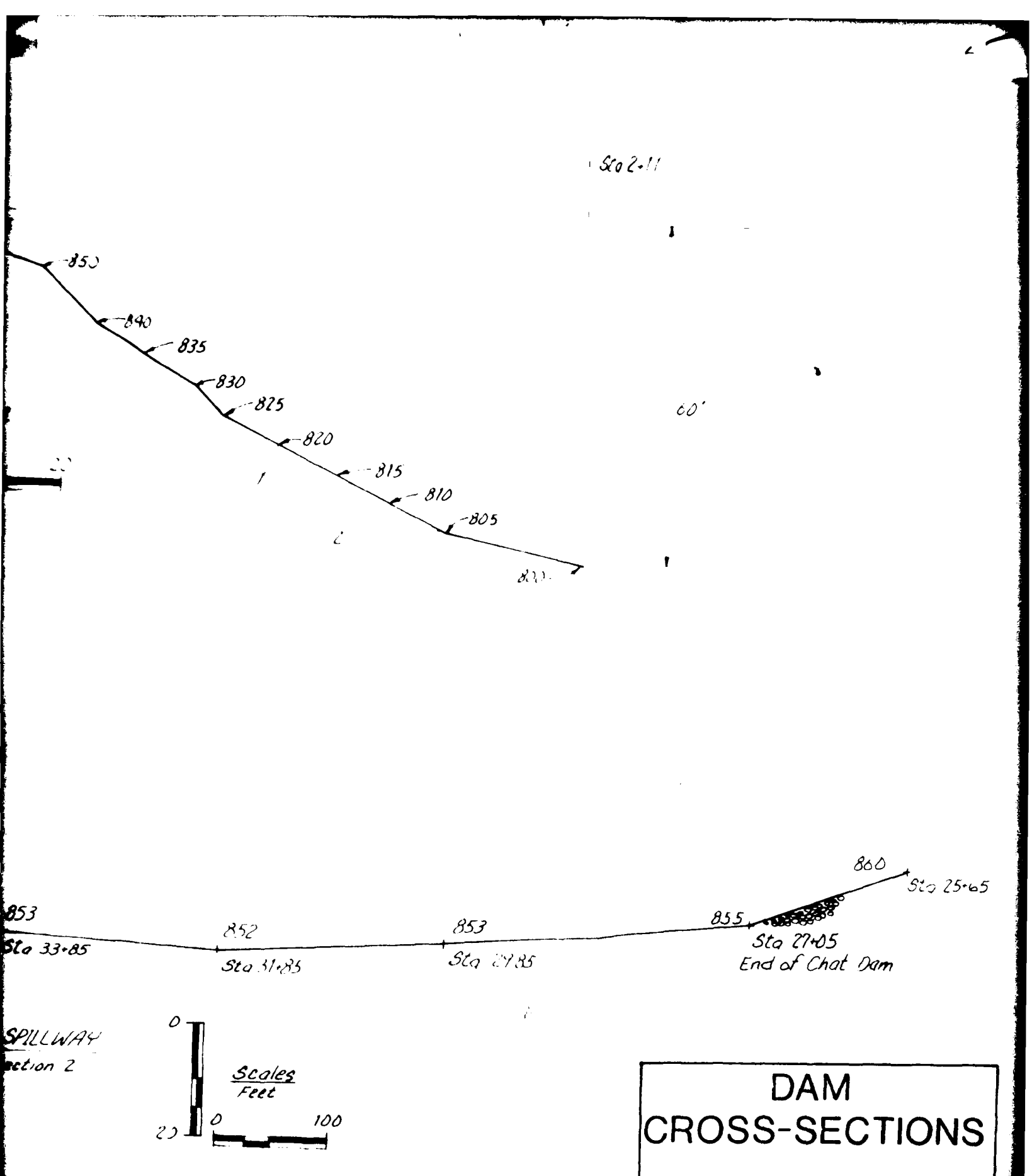
MO 30726 | FIG 3A



MAXIMUM CROSS SECTION
Cross-Section #1



INFORMAL SPILLWAY
Cross-Section 2



DAM CROSS-SECTIONS

DITCH CREEK

MO 30726 | FIG. 3B

Legend

- Or — Roubidoux Formation
- Gasconade Dolomite
  - Gunter Sandstone Member
- Cep — Eminence Dolomite
- Potosi Dolomite
- Derby-Doerun Dolomite
- Davis Formation
- Bonneterre Formation
  - Whetstone Creek Member
  - Sullivan Siltstone Member
- Reagan Sandstone (subsurface, western Missouri)
- Lamotte Sandstone
- Diabase (dikes and sills)
- St. Francois Mountains Intrusive Suite
- St. Francois Mountains Volcanic Supergroup

REGIONAL GEOLOGIC MAP

DITCH CREEK DAM

MO. 30726 | **Fig. 4**

APPENDIX A

Photographs

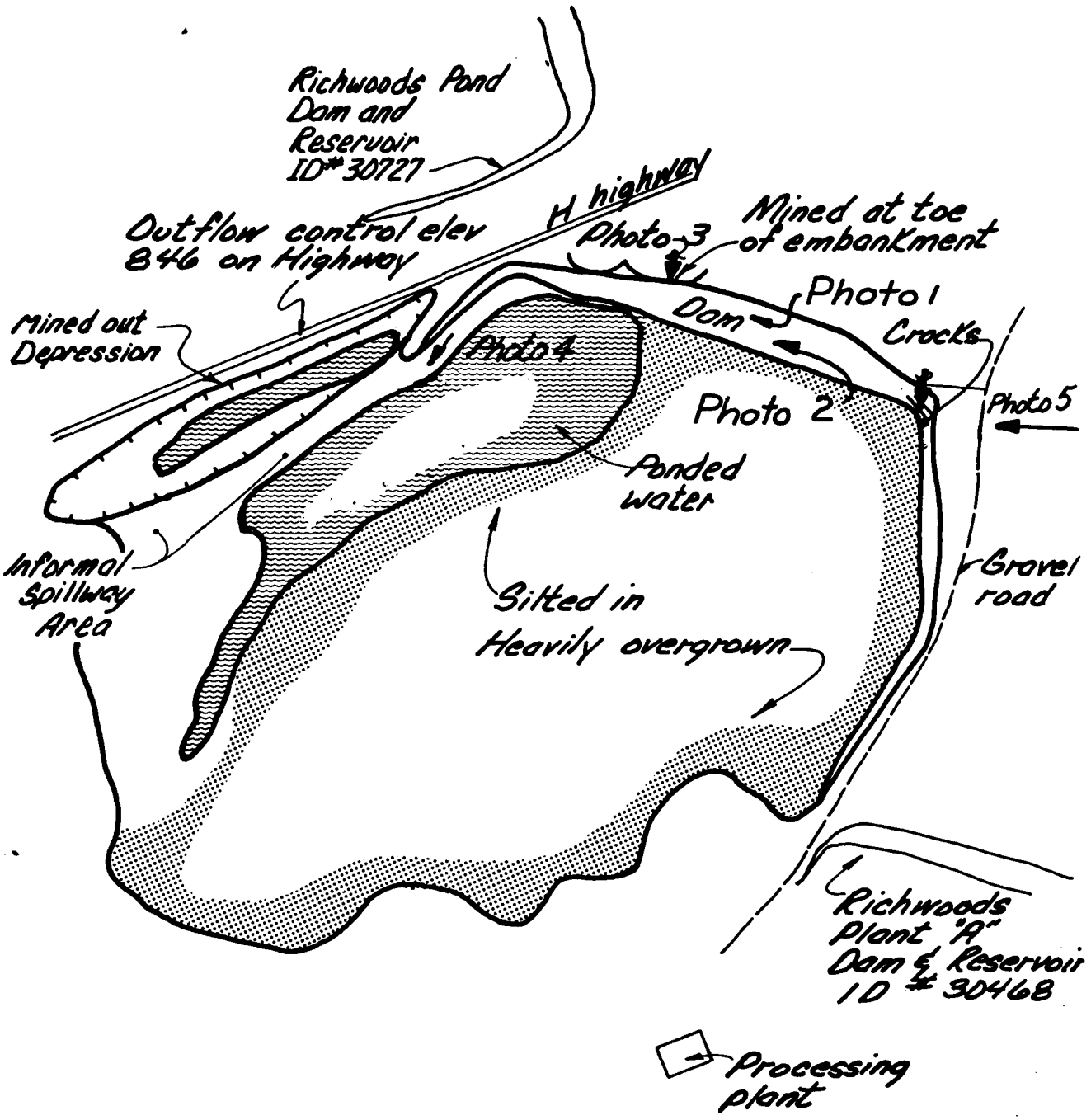
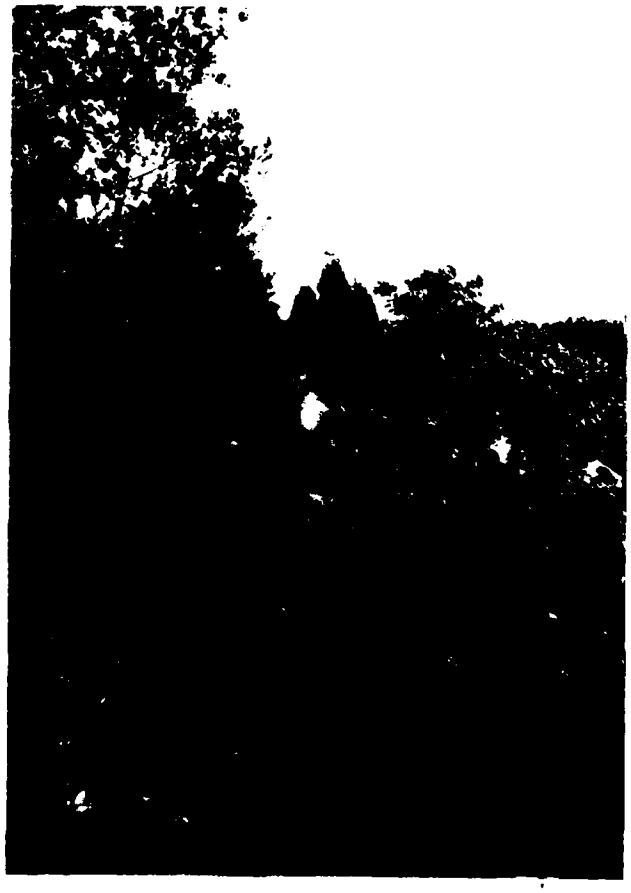


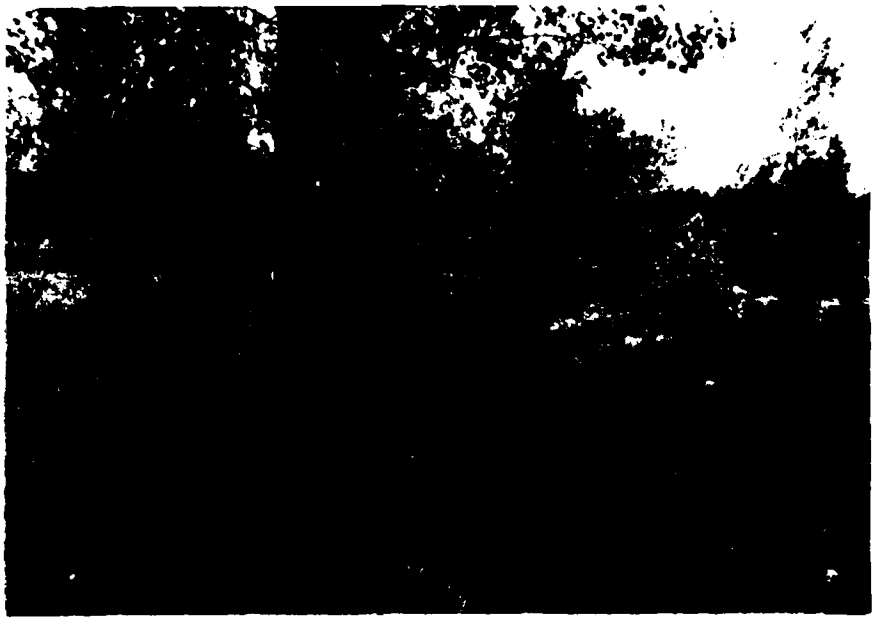
PHOTO LOCATION SKETCH	
DITCH CREEK DAM	
MO. 30726	Fig. A-1

1. Vegetation on face of dam. Variation in density of vegetation apparently reflects variation in embankment material. Looking west.

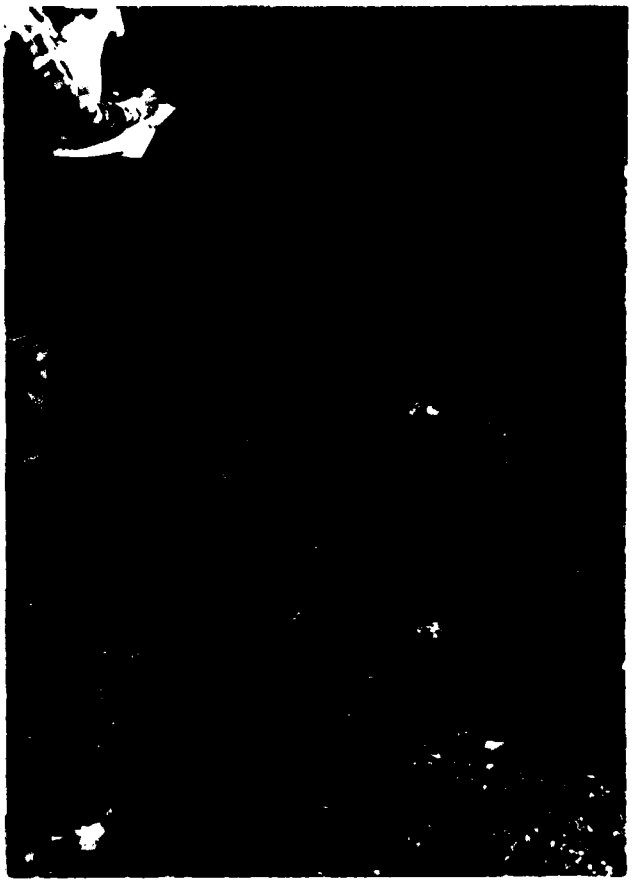


2. Vegetation on crest of dam. Looking west. Impoundment is to the left.

3. Mined area at toe of embankment, near left abutment.



4. Mined area adjacent to reservoir overflow. Looking southwest from end of embankment.



5. Crack in dam showing .3 foot offset down toward the downstream face. Looking south along dam crest.

APPENDIX B

Hydraulic/Hydrologic Data and Analyses

APPENDIX B

Hydraulic/Hydrologic Analyses

B.1 Procedures

a. **General.** The hydraulic/hydrologic analyses were performed using the "HEC-1, Dam Safety Version (1 Apr 80)" computer program. Inflow hydrographs were developed by applying various precipitation events to a synthetic unit hydrograph. The inflow hydrographs, thus obtained, were then routed through the reservoir and appurtenant structures by the modified Puls reservoir routing method used in the HEC-1 program to determine overtopping potential.

b. **Precipitation events.** Various percentages including 100 percent of the Probable Maximum Precipitation (PMP) and the 1 and 10 percent probability-of-occurrence events were used in the analyses. The PMP was determined from regional charts prepared by the US Weather Bureau (1956). The 1 and 10 percent probability-of-occurrence events were provided by SLD.

c. **Unit hydrograph.** The Soil Conservation Service (SCS) unit hydrograph (SCS, 1971) for a storm duration of 48 hrs was used to develop the inflow hydrograph. The unit hydrograph was divided into 10 min increments.

d. **Infiltration losses.** The SCS curve number (CN) method was used to compute infiltration losses. Curve numbers were selected on the basis of antecedent moisture conditions in accordance with the guidelines, present land usage and hydrologic soil group of the soils in the drainage basin. Where more than one soil group was present, the group giving the highest CN was used for the entire basin.

e. **Lag time.** Lag time was computed by the SCS method (National Engineering Handbook, Section 4, Equation 15-4).

B.2 Pertinent Data

a. **Drainage area:** 0.20 mi^2

b. **Lag time:** 0.58 hr

c. **Hydrologic soil group:** C

d. **SCS curve numbers.**

1. For PMF: 91 (AMC III)
2. For 1 and 10 percent probability-of-occurrence events: 80 (AMCII)

e. **Storage.** Elevation-area data were developed by planimetering areas at various elevation contours on the USGS Richwoods NE 7.5-minute quadrangle map. The data were entered on the $A and $E cards so that the HEC-1 program could compute storage volumes.

f. **Outflow capacity.** The elevation - discharge relationship was developed from cross-sections of the informal spillway.

g. **Outflow over informal spillway.** As the profile of the informal spillway crest is irregular, flow over the crest cannot be determined by conventional weir formulas. Crest length-elevation data and hydraulic constants for the crest were entered on $D, $L and $V cards. "Outflow over the crest" is actually taken as flow over elevation 852.

h. **Reservoir elevations.** For all fractions of the PMF and the 1 and 10 percent probability-of-occurrence events, the starting reservoir elevation was the informal spillway crest elevation of 852 ft.

B.3 Results

The results of the analyses as well as the input values to the HEC-I program follow in this Appendix. Only the results summaries are included, not the intermediate output. Complete copies of the HEC-I output are available in our office.

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  01 APR 80
**********
    1                A1       DAM NO. 30726 - MONONAME 999,SOUTHEAST OF RICHWOOD,MISSOURI
    2                A2       WOODWARD-CLYDE CONSULTANTS, HOUSTON JOB 79CH009.
    3                A3       PROBABLE MAXIMUM FLOODS (PMF) ANALYSIS.
    4                B     288         0        10        -0        -0        -0        -0        -0        -0        -0
    5                B1      5
    6                J       1         2         1
    7                J1    .50      1.00
    8                K       0      Q-IN                                                                    1
    9                K1   DAM NO. 30726 INFLOW COMPUTATION, PMF RATIO FLOODS.
   10                M       1         2      0.20                                                     1.0
   11                P       0      26.       102       120       130       140
   12                T                                                                          -1       -91              0.60
   13                W2                0.98
   14                X      -1     -.05         5
   15                K       1      DAM                                                                     1
   16                K1   DAM NO. 30726 FLOOD ROUTING, PMP RATIO FLOODS.
   17                Y                                                 1         1
   18                Y1      1                                                                  -852.
   19                SA      0.      21.       62.       82.       91.
   20                SE   850.     853.      855.      860.      865.
   21                SS   852.              2.6       1.5
   22                SD   852.      2.6       1.5
   23                SL      0.     400.      645.      890.      935.      985.
   24                SV   852.     853.      854.      855.      856.      857.
   25                K      99
```

Ditch Creek Dam
PMF Analysis
Input Data
MO ID No. 30726

```
**********
FLOOD HYDROGRAPH PACKAGE (HEC-1)
DAM SAFETY VERSION      JULY 1978
  LAST MODIFICATION  01 APR 80
**********

RUN  DATE: 05 SEP 90
     TIME: 13.17.50


                    DAM NO. 30726 = MONONAME 594.SOUTHEAST OF RICHWOOD.MISSOURI
                    WOODWARD-CLYDE CONSULTANTS. HOUSTON JOB 79CH009.
                    PROBABLE MAXIMUM FLOODS (PMF) ANALYSIS.

                                        JOB SPECIFICATION
                      NO      NHR     NMIN     IDAY     IHR     IMIN    METRC     IPLT     IPRT   NSTAN
                     288        0       10       -0      -0       -0       -0       -0       -0       -0
                                        JOPER      NWT   LROPT   TRACE
                                            5       -0      -0      -0

                                    MULTI-PLAN ANALYSES TO BE PERFORMED
                                                NPLAN= 1 NRTIO= 2 LRTIO= 1
                          RTIOS=     .50    1.00

**********          **********          **********          **********          **********

                                    SUB-AREA RUNOFF COMPUTATION

                    DAM NO. 30726 INFLOW COMPUTATION. PMP RATIO FLOODS.

                                ISTAQ    ICOMP    IECON    ITAPE     JPLT     JPRT    INAME   ISTAGE   IAUTO
                                 0-IN        0       -0       -0       -0       -0        1       -0       -0

                                        HYDROGRAPH DATA
                      IHYDG     IUNG    TAREA     SNAP   TRSDA   TRSPC   RATIO   ISNOW   ISAME   LOCAL
                          1        2      .20       -0.     .20    1.00      -0.      -0      -0      -0

                                        PRECIP DATA
                                SPFE      PMS       R6      R12      R24      R48      R72      R96
                                  0.    26.00   102.00   120.00   130.00   140.00       -0.      -0.

                                        LOSS DATA
                      LROPT   STRKR   DLTKR   RTIOL   ERAIN   STRKS   RTIOK   STRTL   CNSTL   ALSMX   RTIMP
                         -0      -0.     -0.    1.00      -0.     -0.    1.00   -1.00  -91.00      -0.     .60

                    CURVE NO =  -91.00  WETNESS =   -1.00  EFFECT CN =   91.00

                                        UNIT HYDROGRAPH DATA
                                    TC= -0.      LAG=   .58
```

Ditch Creek Dam
PMF Analysis
Input Data (cont.)
MO ID No. 30726

B4

RECESSION DATA

STRTQ= -1.00 QRCSN= -.05 RTIOR= 5.00

UNIT HYDROGRAPH 19 END OF PERIOD ORDINATES, TC= -0. HOURS, LAG= .58 VOL= 1.00

21. 69. 128. 146. 130. 98. 61. 40. 28. 18.

12. 8. 5. 4. 2. 2. 1. 1. 0.

0

END-OF-PERIOD FLOW

MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q	MO.DA	HR.MN	PERIOD	RAIN	EXCS	LOSS	COMP Q
1.01	.10	1	.00	.00	.00	0.	1.02	.10	145	.03	.03	.00	3.
1.01	.20	2	.00	.00	.00	0.	1.02	.20	146	.03	.03	.00	5.
1.01	.30	3	.00	.00	.00	0.	1.02	.30	147	.03	.03	.00	8.
1.01	.40	4	.00	.00	.00	1.	1.02	.40	148	.03	.03	.00	11.
1.01	.50	5	.00	.00	.00	1.	1.02	.50	149	.03	.03	.00	15.
1.01	1.00	6	.00	.00	.00	1.	1.02	1.00	150	.03	.03	.00	17.
1.01	1.10	7	.00	.00	.00	1.	1.02	1.10	151	.03	.03	.00	19.
1.01	1.20	8	.00	.00	.00	1.	1.02	1.20	152	.03	.03	.00	20.
1.01	1.30	9	.00	.00	.00	1.	1.02	1.30	153	.03	.03	.00	20.
1.01	1.40	10	.00	.00	.00	1.	1.02	1.40	154	.03	.03	.00	21.
1.01	1.50	11	.00	.00	.00	1.	1.02	1.50	155	.03	.03	.00	21.
1.01	2.00	12	.00	.00	.00	1.	1.02	2.00	156	.03	.03	.00	21.
1.01	2.10	13	.00	.00	.00	1.	1.02	2.10	157	.03	.03	.00	21.
1.01	2.20	14	.00	.00	.00	1.	1.02	2.20	158	.03	.03	.00	22.
1.01	2.30	15	.00	.00	.00	1.	1.02	2.30	159	.03	.03	.00	22.
1.01	2.40	16	.00	.00	.00	1.	1.02	2.40	160	.03	.03	.00	22.
1.01	2.50	17	.00	.00	.00	1.	1.02	2.50	161	.03	.03	.00	22.
1.01	3.00	18	.00	.00	.00	1.	1.02	3.00	162	.03	.03	.00	22.
1.01	3.10	19	.00	.00	.00	1.	1.02	3.10	163	.03	.03	.00	22.
1.01	3.20	20	.00	.00	.00	1.	1.02	3.20	164	.03	.03	.00	22.
1.01	3.30	21	.00	.00	.00	1.	1.02	3.30	165	.03	.03	.00	22.
1.01	3.40	22	.00	.00	.00	1.	1.02	3.40	166	.03	.03	.00	22.
1.01	3.50	23	.00	.00	.00	1.	1.02	3.50	167	.03	.03	.00	22.
1.01	4.00	24	.00	.00	.00	1.	1.02	4.00	168	.03	.03	.00	22.
1.01	4.10	25	.00	.00	.00	1.	1.02	4.10	169	.03	.03	.00	22.
1.01	4.20	26	.00	.00	.00	1.	1.02	4.20	170	.03	.03	.00	22.
1.01	4.30	27	.00	.00	.00	1.	1.02	4.30	171	.03	.03	.00	22.
1.01	4.40	28	.00	.00	.00	1.	1.02	4.40	172	.03	.03	.00	22.
1.01	4.50	29	.00	.00	.00	1.	1.02	4.50	173	.03	.03	.00	22.
1.01	5.00	30	.00	.00	.00	1.	1.02	5.00	174	.03	.03	.00	22.
1.01	5.10	31	.00	.00	.00	1.	1.02	5.10	175	.03	.03	.00	22.
1.01	5.20	32	.00	.00	.00	1.	1.02	5.20	176	.03	.03	.00	22.
1.01	5.30	33	.00	.00	.00	1.	1.02	5.30	177	.03	.03	.00	22.
1.01	5.40	34	.00	.00	.00	1.	1.02	5.40	178	.03	.03	.00	22.
1.01	5.50	35	.00	.00	.00	1.	1.02	5.50	179	.03	.03	.00	22.
1.01	6.00	36	.00	.00	.00	1.	1.02	6.00	180	.03	.03	.00	22.
1.01	6.10	37	.01	.01	.00	1.	1.02	6.10	181	.13	.13	.00	24.
1.01	6.20	38	.01	.01	.00	1.	1.02	6.20	182	.13	.13	.00	31.
1.01	6.30	39	.01	.01	.00	2.	1.02	6.30	183	.13	.13	.00	44.
1.01	6.40	40	.01	.01	.00	3.	1.02	6.40	184	.13	.13	.00	59.
1.01	6.50	41	.01	.01	.00	3.	1.02	6.50	185	.13	.13	.00	71.
1.01	7.00	42	.01	.01	.00	4.	1.02	7.00	186	.13	.13	.00	81.
1.01	7.10	43	.01	.01	.00	4.	1.02	7.10	187	.13	.13	.00	87.
1.01	7.20	44	.01	.01	.00	4.	1.02	7.20	188	.13	.13	.00	91.
1.01	7.30	45	.01	.01	.00	4.	1.02	7.30	189	.13	.13	.00	94.
1.01	7.40	46	.01	.01	.00	4.	1.02	7.40	190	.13	.13	.00	96.
1.01	7.50	47	.01	.01	.00	5.	1.02	7.50	191	.13	.13	.00	97.
1.01	8.00	48	.01	.01	.00	5.	1.02	8.00	192	.13	.13	.00	98.
1.01	8.10	49	.01	.01	.00	5.	1.02	8.10	193	.13	.13	.00	98.

Ditch Creek Dam
PMF Analysis
Input Data (cont.)
MO ID No. 30726

B5

1.01	8.20	50	.01	.01	.00	5.	1.02	8.20	194	.13	.13	.00	99.
1.01	8.30	51	.01	.01	.00	5.	1.02	8.30	195	.13	.13	.00	99.
1.01	8.40	52	.01	.01	.00	5.	1.02	8.40	196	.13	.13	.00	99.
1.01	8.50	53	.01	.01	.00	5.	1.02	8.50	197	.13	.13	.00	99.
1.01	9.00	54	.01	.01	.00	5.	1.02	9.00	198	.13	.13	.00	100.
1.01	9.10	55	.01	.01	.00	5.	1.02	9.10	199	.13	.13	.00	100.
1.01	9.20	56	.01	.01	.00	5.	1.02	9.20	200	.13	.13	.00	100.
1.01	9.30	57	.01	.01	.00	5.	1.02	9.30	201	.13	.13	.00	100.
1.01	9.40	58	.01	.01	.00	5.	1.02	9.40	202	.13	.13	.00	100.
1.01	9.50	59	.01	.01	.00	5.	1.02	9.50	203	.13	.13	.00	100.
1.01	10.00	60	.01	.01	.00	5.	1.02	10.00	204	.13	.13	.00	100.
1.01	10.10	61	.01	.01	.00	5.	1.02	10.10	205	.13	.13	.00	100.
1.01	10.20	62	.01	.01	.00	5.	1.02	10.20	206	.13	.13	.00	100.
1.01	10.30	63	.01	.01	.00	5.	1.02	10.30	207	.13	.13	.00	100.
1.01	10.40	64	.01	.01	.00	5.	1.02	10.40	208	.13	.13	.00	100.
1.01	10.50	65	.01	.01	.00	5.	1.02	10.50	209	.13	.13	.00	100.
1.01	11.00	66	.01	.01	.00	5.	1.02	11.00	210	.13	.13	.00	100.
1.01	11.10	67	.01	.01	.00	5.	1.02	11.10	211	.13	.13	.00	100.
1.01	11.20	68	.01	.01	.00	5.	1.02	11.20	212	.13	.13	.00	100.
1.01	11.30	69	.01	.01	.00	5.	1.02	11.30	213	.13	.13	.00	100.
1.01	11.40	70	.01	.01	.00	6.	1.02	11.40	214	.13	.13	.00	100.
1.01	11.50	71	.01	.01	.00	6.	1.02	11.50	215	.13	.13	.00	100.
1.01	12.00	72	.01	.01	.00	6.	1.02	12.00	216	.13	.13	.00	100.
1.01	12.10	73	.03	.03	.01	6.	1.02	12.10	217	.44	.44	.00	107.
1.01	12.20	74	.03	.03	.01	7.	1.02	12.20	218	.44	.44	.00	126.
1.01	12.30	75	.03	.03	.01	10.	1.02	12.30	219	.44	.44	.00	169.
1.01	12.40	76	.03	.03	.01	12.	1.02	12.40	220	.44	.44	.00	212.
1.01	12.50	77	.03	.03	.01	15.	1.02	12.50	221	.44	.44	.00	254.
1.01	13.00	78	.03	.03	.01	17.	1.02	13.00	222	.44	.44	.00	284.
1.01	13.10	79	.04	.03	.01	19.	1.02	13.10	223	.53	.53	.00	309.
1.01	13.20	80	.04	.03	.01	20.	1.02	13.20	224	.53	.53	.00	324.
1.01	13.30	81	.04	.03	.01	21.	1.02	13.30	225	.53	.53	.00	344.
1.01	13.40	82	.04	.03	.01	23.	1.02	13.40	226	.53	.53	.00	362.
1.01	13.50	83	.04	.03	.01	24.	1.02	13.50	227	.53	.53	.00	378.
1.01	14.00	84	.04	.04	.01	25.	1.02	14.00	228	.53	.53	.00	389.
1.01	14.10	85	.05	.04	.01	26.	1.02	14.10	229	.66	.66	.00	399.
1.01	14.20	86	.05	.04	.01	27.	1.02	14.20	230	.66	.66	.00	413.
1.01	14.30	87	.05	.04	.01	28.	1.02	14.30	231	.66	.66	.00	433.
1.01	14.40	88	.05	.05	.01	30.	1.02	14.40	232	.66	.66	.00	454.
1.01	14.50	89	.05	.05	.01	32.	1.02	14.50	233	.66	.66	.00	473.
1.01	15.00	90	.05	.05	.01	33.	1.02	15.00	234	.66	.66	.00	487.
1.01	15.10	91	.05	.04	.00	33.	1.02	15.10	235	.60	.60	.00	494.
1.01	15.20	92	.08	.07	.01	34.	1.02	15.20	236	1.01	1.01	.00	500.
1.01	15.30	93	.14	.13	.01	38.	1.02	15.30	237	1.81	1.81	.00	546.
1.01	15.40	94	.35	.33	.02	49.	1.02	15.40	238	4.53	4.53	.00	766.
1.01	15.50	95	.10	.10	.01	69.	1.02	15.50	239	1.31	1.31	.00	961.
1.01	16.00	96	.06	.06	.00	90.	1.02	16.00	240	.81	.81	.00	1261.
1.01	16.10	97	.05	.05	.00	96.	1.02	16.10	241	.62	.62	.00	1347.
1.01	16.20	98	.05	.05	.00	90.	1.02	16.20	242	.62	.62	.00	1294.
1.01	16.30	99	.05	.05	.00	77.	1.02	16.30	243	.62	.62	.00	1089.
1.01	16.40	100	.05	.05	.00	63.	1.02	16.40	244	.62	.62	.00	869.
1.01	16.50	101	.05	.05	.00	53.	1.02	16.50	245	.62	.62	.00	726.
1.01	17.00	102	.05	.05	.00	47.	1.02	17.00	246	.62	.62	.00	642.
1.01	17.10	103	.04	.04	.00	43.	1.02	17.10	247	.49	.49	.00	591.
1.01	17.20	104	.04	.04	.00	40.	1.02	17.20	248	.49	.49	.00	549.
1.01	17.30	105	.04	.04	.00	37.	1.02	17.30	249	.49	.49	.00	500.
1.01	17.40	106	.04	.04	.00	34.	1.02	17.40	250	.49	.49	.00	464.

Ditch Creek Dam
PMF Analysis
Input Data (cont.)
MO ID No. 30726

B6

1.01	17.50	107	.04	.04	.00	32.	1.02	17.50	251	.49	.49	.00	432.
1.01	18.00	108	.04	.04	.00	31.	1.02	18.00	252	.49	.49	.00	419.
1.01	18.10	109	.00	.00	.00	29.	1.02	18.10	253	.04	.04	.00	393.
1.01	18.20	110	.00	.00	.00	26.	1.02	18.20	254	.04	.04	.00	354.
1.01	18.30	111	.00	.00	.00	21.	1.02	18.30	255	.04	.04	.00	291.
1.01	18.40	112	.00	.00	.00	16.	1.02	18.40	256	.04	.04	.00	221.
1.01	18.50	113	.00	.00	.00	12.	1.02	18.50	257	.04	.04	.00	161.
1.01	19.00	114	.00	.00	.00	9.	1.02	19.00	258	.04	.04	.00	116.
1.01	19.10	115	.00	.00	.00	7.	1.02	19.10	259	.04	.04	.00	88.
1.01	19.20	116	.00	.00	.00	5.	1.02	19.20	260	.04	.04	.00	70.
1.01	19.30	117	.00	.00	.00	4.	1.02	19.30	261	.04	.04	.00	55.
1.01	19.40	118	.00	.00	.00	4.	1.02	19.40	262	.04	.04	.00	51.
1.01	19.50	119	.00	.00	.00	3.	1.02	19.50	263	.04	.04	.00	44.
1.01	20.00	120	.00	.00	.00	3.	1.02	20.00	264	.04	.04	.00	40.
1.01	20.10	121	.00	.00	.00	3.	1.02	20.10	265	.04	.04	.00	39.
1.01	20.20	122	.00	.00	.00	3.	1.02	20.20	266	.04	.04	.00	39.
1.01	20.30	123	.00	.00	.00	3.	1.02	20.30	267	.04	.04	.00	39.
1.01	20.40	124	.00	.00	.00	3.	1.02	20.40	268	.04	.04	.00	34.
1.01	20.50	125	.00	.00	.00	3.	1.02	20.50	269	.04	.04	.00	34.
1.01	21.00	126	.00	.00	.00	2.	1.02	21.00	270	.04	.04	.00	34.
1.01	21.10	127	.00	.00	.00	2.	1.02	21.10	271	.04	.04	.00	34.
1.01	21.20	128	.00	.00	.00	2.	1.02	21.20	272	.04	.04	.00	34.
1.01	21.30	129	.00	.00	.00	2.	1.02	21.30	273	.04	.04	.00	34.
1.01	21.40	130	.00	.00	.00	2.	1.02	21.40	274	.04	.04	.00	34.
1.01	21.50	131	.00	.00	.00	2.	1.02	21.50	275	.04	.04	.00	34.
1.01	22.00	132	.00	.00	.00	2.	1.02	22.00	276	.04	.04	.00	34.
1.01	22.10	133	.00	.00	.00	2.	1.02	22.10	277	.04	.04	.00	34.
1.01	22.20	134	.00	.00	.00	2.	1.02	22.20	278	.04	.04	.00	34.
1.01	22.30	135	.00	.00	.00	2.	1.02	22.30	279	.04	.04	.00	34.
1.01	22.40	136	.00	.00	.00	2.	1.02	22.40	280	.04	.04	.00	34.
1.01	22.50	137	.00	.00	.00	2.	1.02	22.50	281	.04	.04	.00	34.
1.01	23.00	138	.00	.00	.00	2.	1.02	23.00	282	.04	.04	.00	34.
1.01	23.10	139	.00	.00	.00	2.	1.02	23.10	283	.04	.04	.00	34.
1.01	23.20	140	.00	.00	.00	2.	1.02	23.20	284	.04	.04	.00	34.
1.01	23.30	141	.00	.00	.00	2.	1.02	23.30	285	.04	.04	.00	34.
1.01	23.40	142	.00	.00	.00	2.	1.02	23.40	286	.04	.04	.00	34.
1.01	23.50	143	.00	.00	.00	2.	1.02	23.50	287	.04	.04	.00	34.
1.02	0.	144	.00	.00	.00	2.	1.03	0.	288	.04	.04	.00	34.
									SUM	36.40	35.94	.46	27669.
										925.11	913.11	12.11	784.071

	PEAK	6-HOUR	24-HOUR	72-HOUR	TOTAL VOLUME
CFS	1347.	553.	180.	96.	27663.
CMS	38.	16.	5.	3.	783.
INCHES		29.74	33.91	39.74	39.74
MM		653.85	851.23	907.80	907.80
AC-FT		274.	357.	381.	381.
THOUS CU M		339.	441.	470.	470.

Ditch Creek Dam
PMF Analysis
Input Data (cont.)
MO ID No. 30726

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

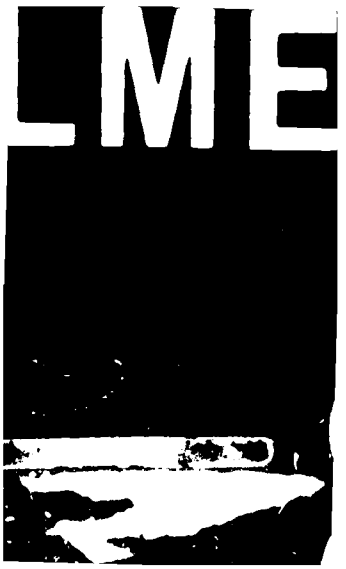
OPERATION	STATION	AREA	PLAN	RATIOS APPLIED TO FLOWS RATIO 1 .50	RATIO 2 1.00
HYDROGRAPH AT	Q-IN	.20	1	673.	1347.
		(.52)	(	19.07)(	38.14)(
ROUTED TO	DAM	.20	1	616.	1264.
		(.52)	(	17.49)(	39.78)(

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1		INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
	ELEVATION	852.00	852.00	852.00
	STORAGE	6.	6.	6.
	OUTFLOW	0.	0.	0.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.50	853.12	1.12	24.	616.	48.00	40.33	0.
1.00	853.49	1.49	33.	1264.	48.00	40.33	0.

Ditch Creek Dam
PMF Overtopping Analysis
Output Data
MO ID No. 30726


LME